A&P/Waldbaum's Supermarket: Capstone 60 with Desiccant Unit

DOE/CETC Workshop on
Microturbine Applications

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Project Team

Host Facility:

- Waldbaums/A&P

Project Sponsors:

- NYSERDA
- KeySpan Gas R&D
- Oak Ridge National Laboratory
- National Renewable Energy Laboratory

Others:

- AGA, Exergy Partners, GTI, EPA/ETV

CHP in Supermarkets

- Peak is 400-600 kW for typical store
- Significant space heating loads due to refrigerated display cases
- Desiccant dehumidification is widely used in supermarkets
  - more than 1,000 desiccant units in US stores
- Good balance between thermal and electrical loads

Project Schedule/Experiences

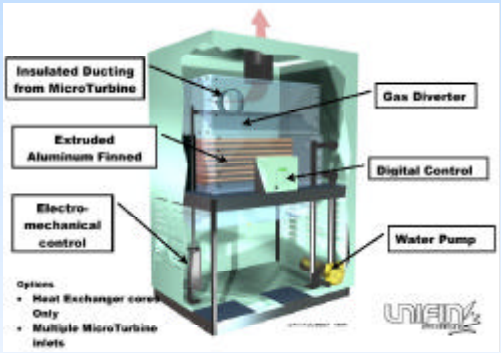
Microturbine installed as add-on to normal supermarket construction cycle

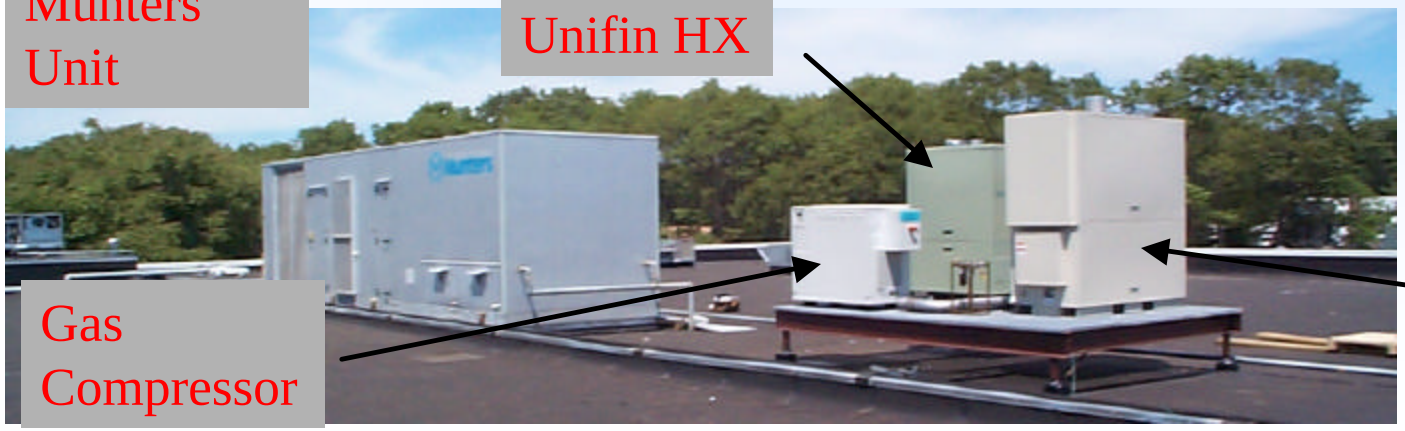
	Plan	Actual
Equipment Received:	Jan02	Jan02
System Commissioned:	Jul02	Aug02
Permission to Operate:	Jul02	**Apr03**
Monitoring Started:	Jul02	Aug02

Utility interconnection issues delayed startup by 8 months!

The CHP System

- Capstone 60 kW Microturbine
- Nat. Gas Compressor (scroll)
- Unifin Heat Exchanger
- Hot Water Coils Installed in Munters Unit

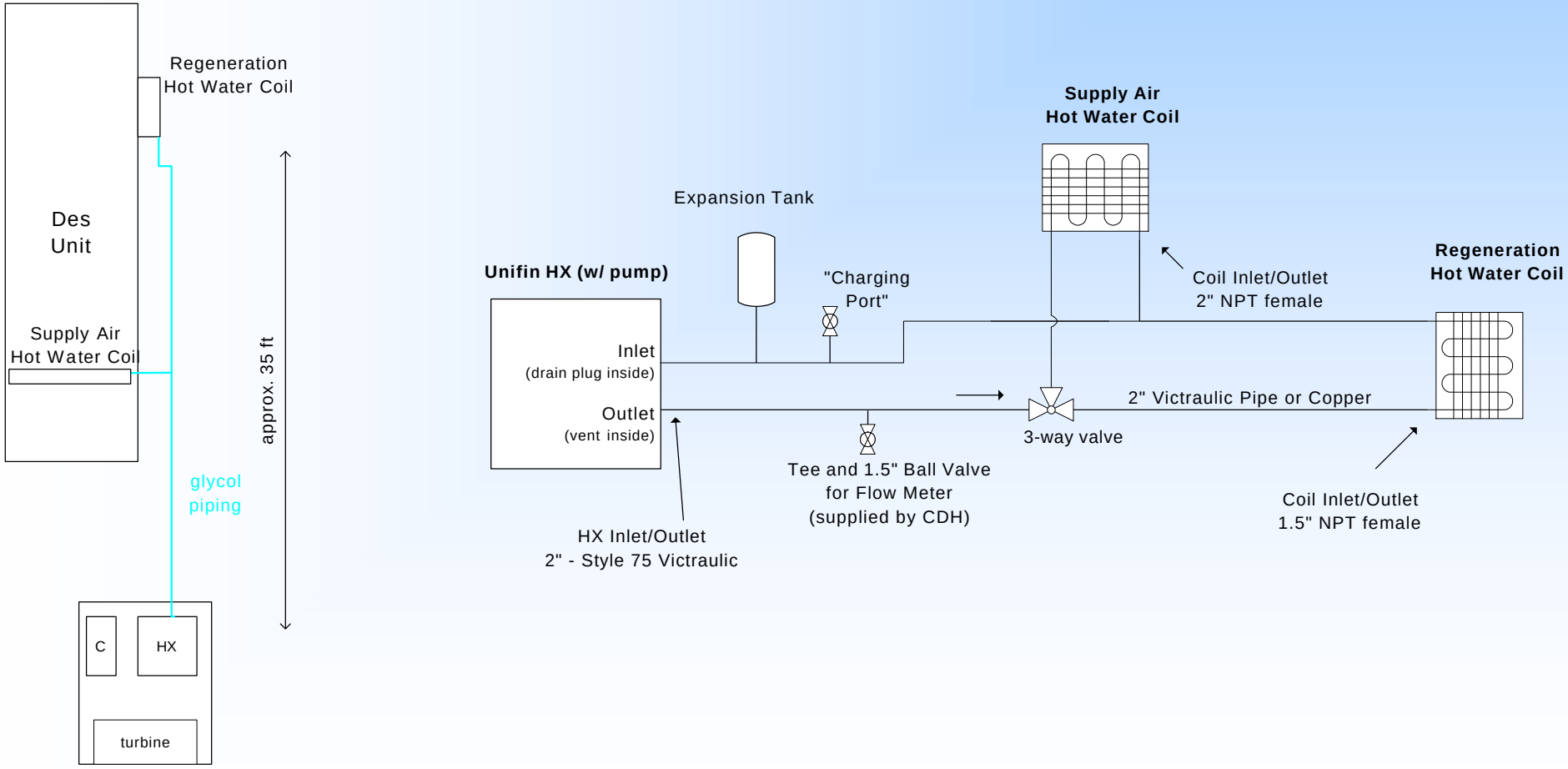




Installed CHP System

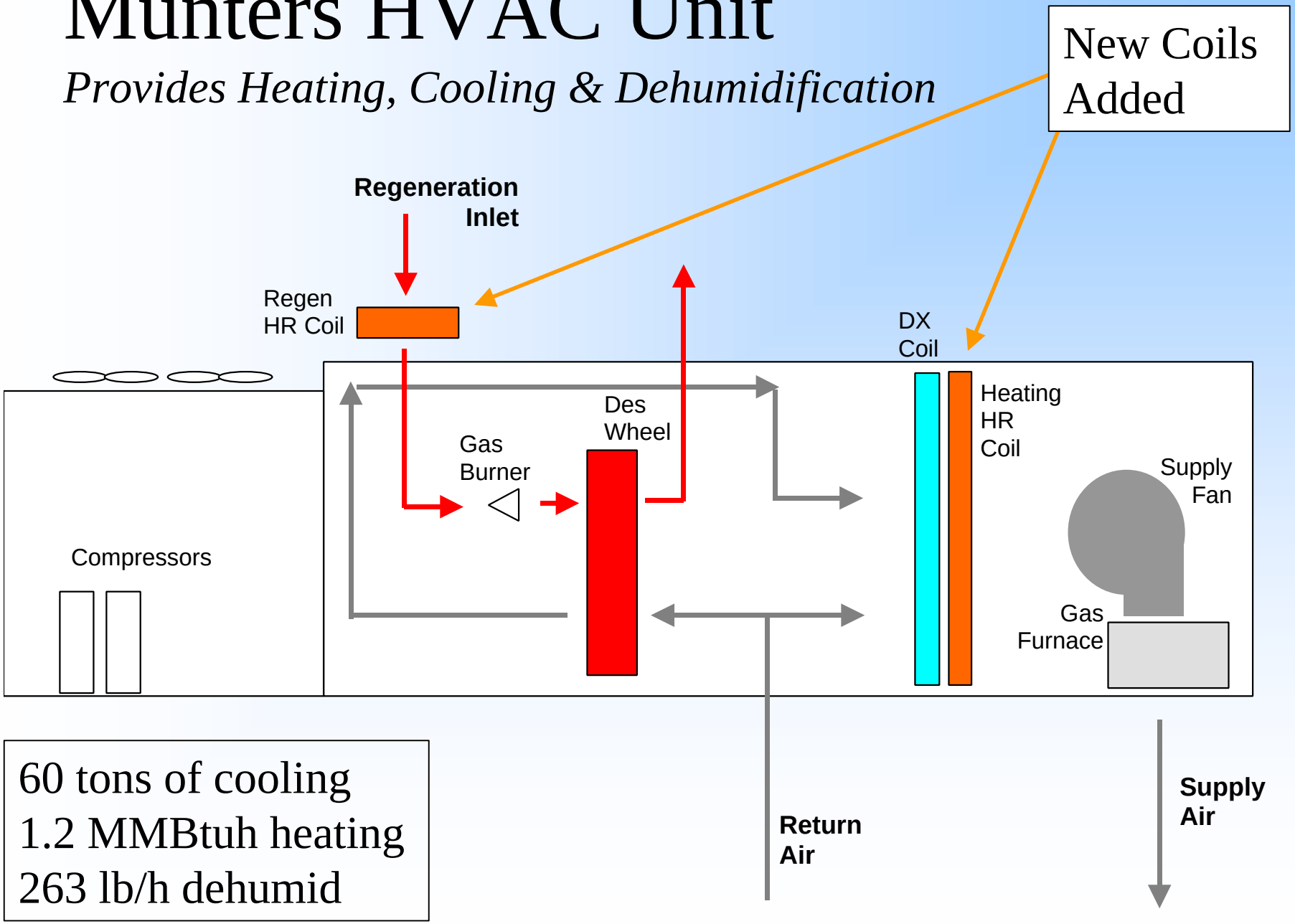
Heat Recovery System

Hot water coils installed in Munters Unit



Munters HVAC Unit

Provides Heating, Cooling & Dehumidification



60 tons of cooling
1.2 MMBtuh heating
263 lb/h dehumid

CHP System Summary

- CHP System sized for thermal loads
  - provide 60 kW of baseload power
  - grid-parallel operation only
  - may consider scheduling turbine operation for periods when heat recovery loads are low
- System can use heat recovery when available *or* Munters systems: fully redundant

System Installation Costs

Microturbine & Unifin HX	$70k
Coils in Munters Unit	$7k
Steel, Roofing, Crane	$20k
Electrical	$8k
Plumbing	$32k
GC Management	$5k
TOTAL	**$142k**

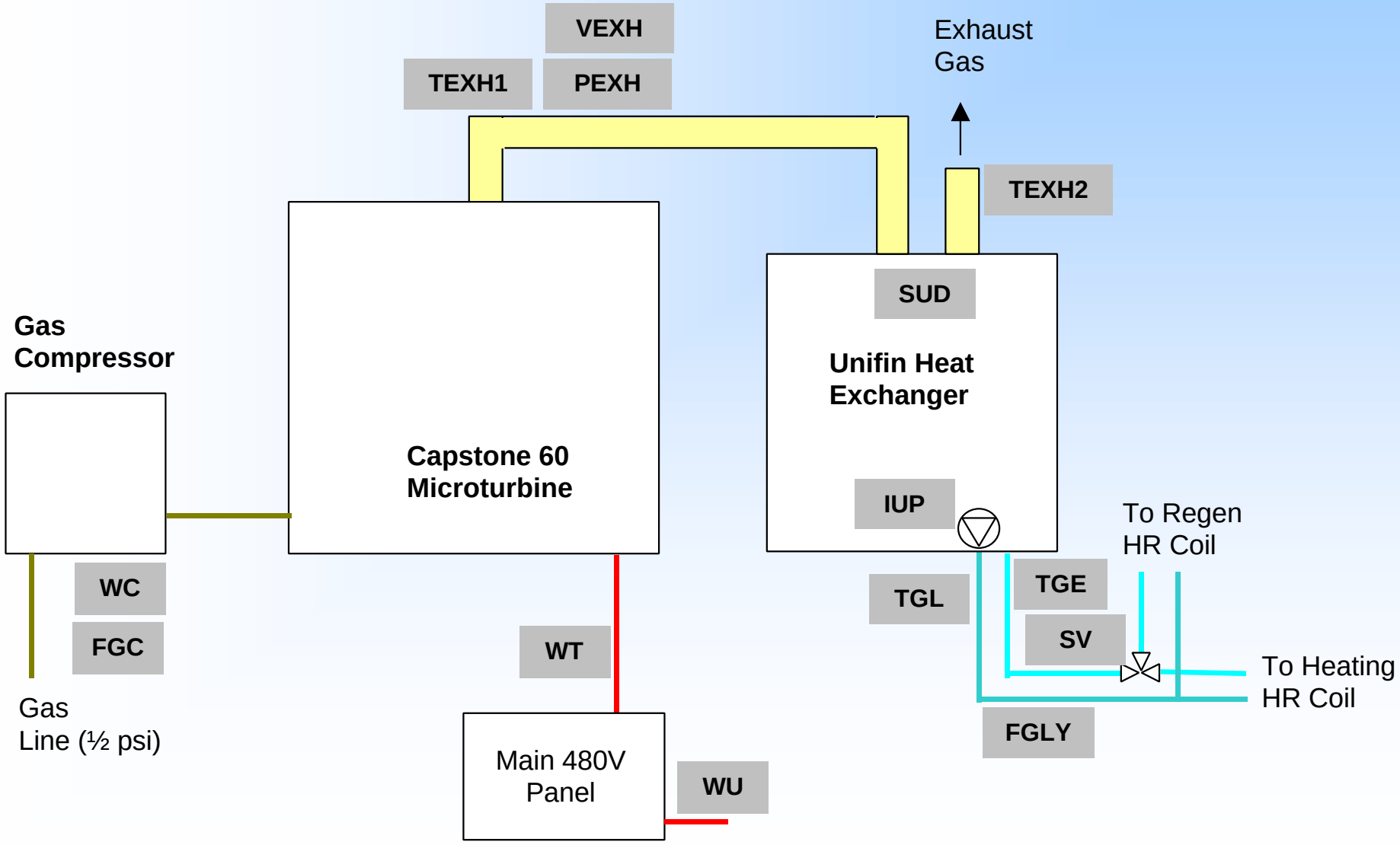
Change Orders & “Metro NY Factor” probably added $30-40k to installation (or $500-700 per kW)

$2360 per kW

Field Monitoring

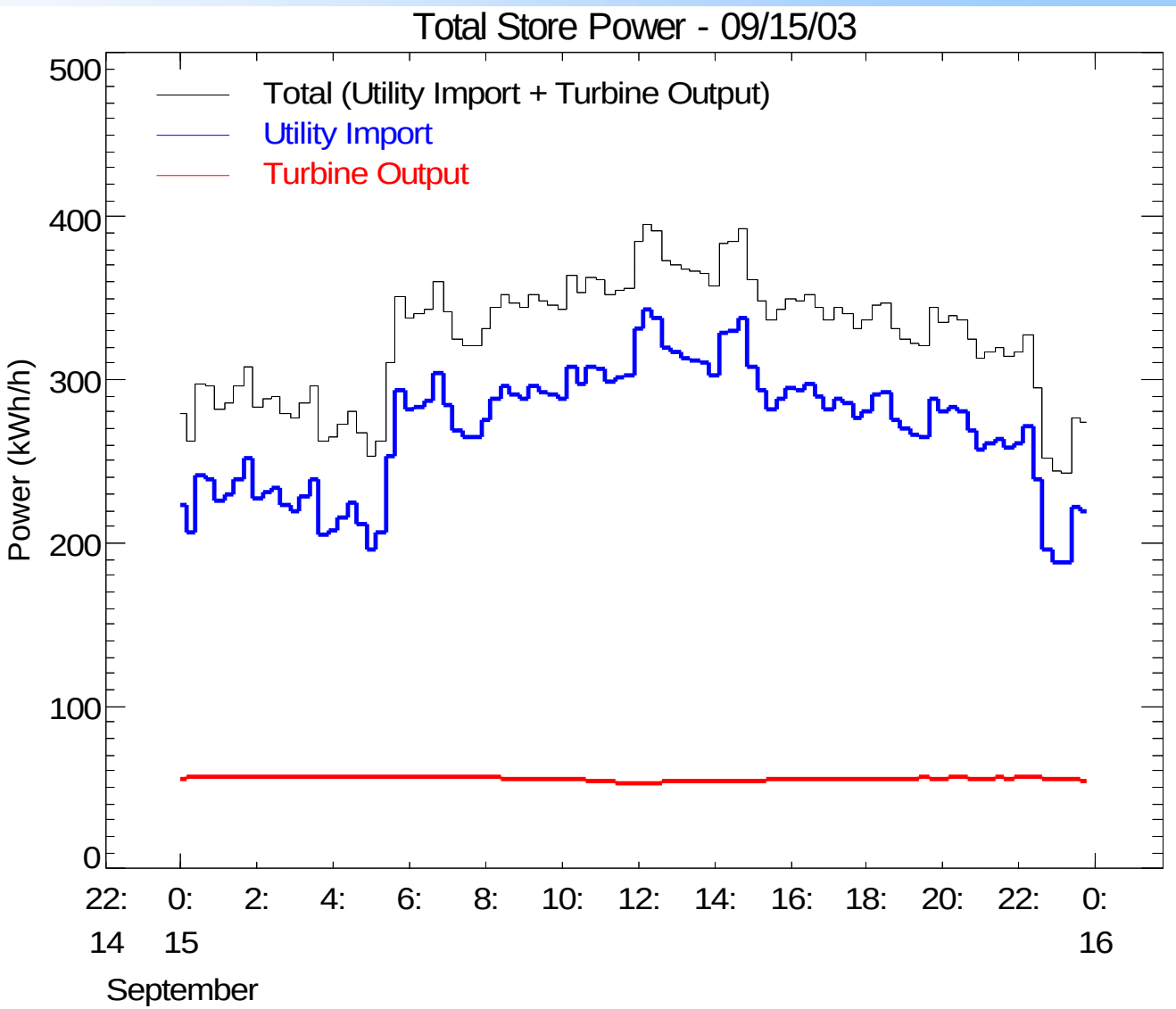
- Installed data logging equipment to quantify thermal and electric performance
  - electrical turbine output (kW, amps, volts)
  - thermal output of Unifin HX (flow, ΔT)
  - turbine exhaust (T, static P, flow)
  - desiccant/HVAC unit performance (T, RH, kW)

CHP Monitoring Points



Turbine Impact on Store

- turbine output PF maintained at 1.0
- Improves store PF
- exceptionally long wiring added 1.5 kW of losses



Peak Total Demand: 395.5 kW @ 12:15 PM

Peak Utility Import Demand: 342.5 kW @ 12:15 PM

Overall CHP Performance

	Turbine		Parasitic Loads		Heat Recovered			
Date	Power Output (kWh)	Gas Input (MBTU)	Gas Compressor (kWh)	Heat Recovery Glycol Pump (kWh)	Space Heating (MBTU)	Desiccant Regen (MBTU)	"Net" Turbine Generation Efficiency (%)	"Net" CHP Efficiency (%)
April-03	15,356	209,649	1,097.3	250.0	16,162	0	23.2%	30.5%
May-03	30,414	411,031	2,113.0	474.6	29,084	2,045	23.5%	30.7%
June-03	39,087	549,741	2,767.1	530.1	18	17,223	22.5%	25.4%
July-03	39,185	568,723	2,878.3	635.8	103	72,102	21.8%	34.1%
August-03	10,864	161,883	838.9	185.7	0	46,035	21.1%	49.2%
September-03	22,210	328,755	1,627.2	359.1	457	40,837	21.4%	33.6%
October-03	33,777	465,929	2,312.4	512.2	21,063	12,828	23.0%	29.9%
November-03	10,005	138,575	693.8	153.3	5,939	6,192	22.9%	31.3%
December-03	5,290	66,833	370.7	81.7	4,688	0	25.1%	31.7%
Totals	***206,187***	***2,901,119***	***14,699***	***3,182***	***77,515***	***197,263***	***22.5%***	***31.6%***

Note: Actual natural gas HHV is used.

$$EFF = \frac{W_{output} - W_{parasitic} + Q_{hr}}{G_{input}}$$

Daily Summer-Time CHP Performance

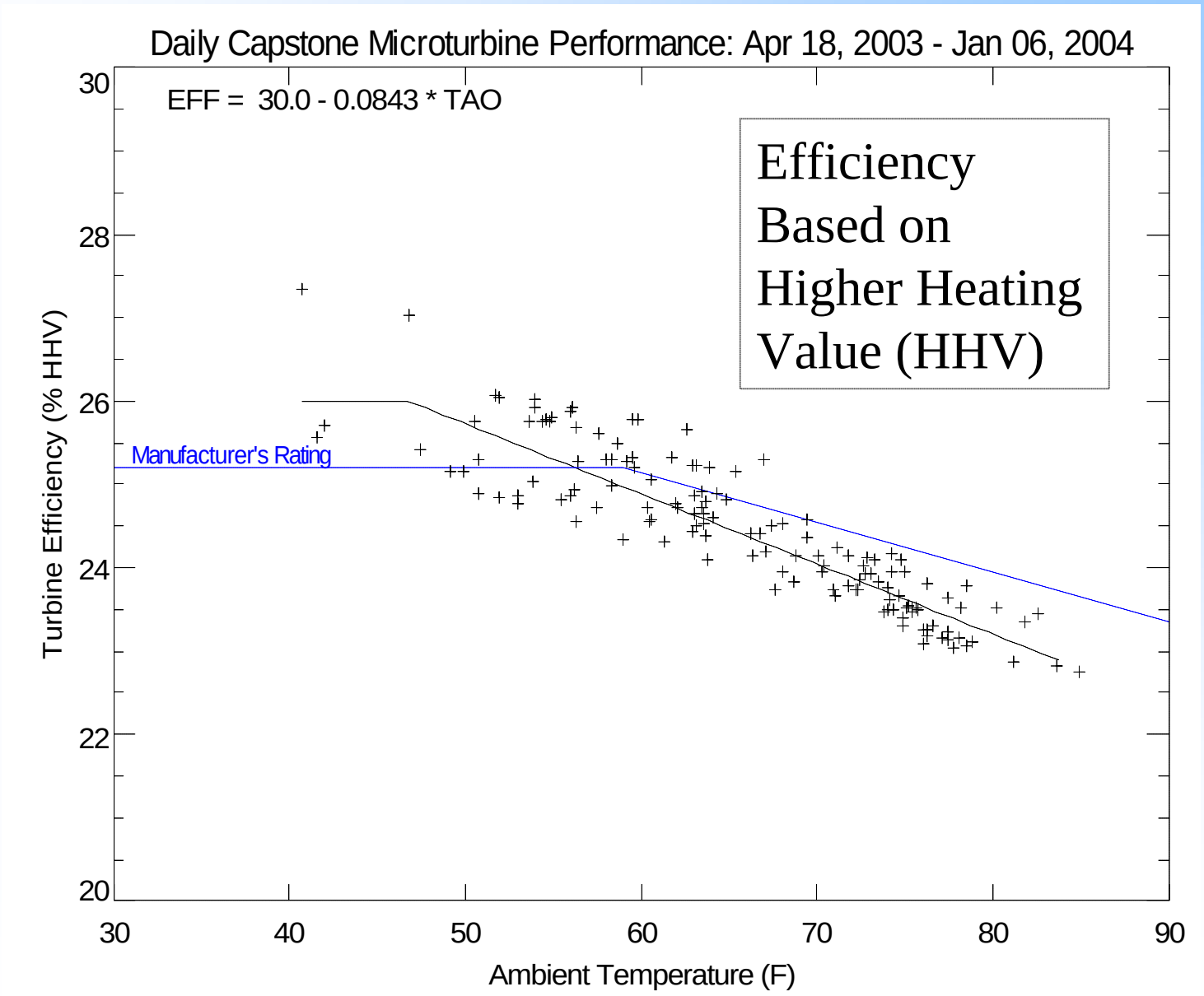
	Turbine		Parasitic Loads		Heat Recovered			[1-3-4+5+6] / [2]
Date	Power Output (kWh)	Gas Input (MBTU)	Gas Compressor (kWh)	Heat Recovery Glycol Pump (kWh)	Space Heating (MBTU)	Desiccant Regen (MBTU)	"Net" Turbine Generation Efficiency (%)	"Net" CHP Efficiency (%)
Aug 1, 2003	1,265.9	18,428	92.9	20.6	0	4,868	21.7%	47.8%
Aug 2, 2003	1,221.1	18,025	93.1	20.6	0	5,310	21.4%	50.4%
Aug 3, 2003	1,223.8	18,025	93.2	20.6	0	5,308	21.4%	50.5%
Aug 4, 2003	1,220.1	17,925	93.0	20.5	0	5,358	21.5%	51.0%
Aug 5, 2003	1,222.1	17,937	92.7	20.6	0	5,434	21.5%	51.4%
Aug 6, 2003	1,210.8	17,836	92.8	20.6	0	4,791	21.4%	47.9%
Aug 7, 2003	1,205.5	17,735	92.8	20.6	0	4,649	21.4%	47.2%
Aug 8, 2003	1,213.4	17,936	92.8	20.6	0	5,193	21.3%	49.9%
Aug 9, 2003	1,222.1	17,936	93.0	20.5	0	5,083	21.5%	49.4%
Aug 10, 2003	22.5	100	1.8	0.4	0	39		
Totals	***10,864***	***161,883***	***839***	***186***	***0***	***46,035***	***21.1%***	***49.2%***

Note: Actual natural gas HHV is used.

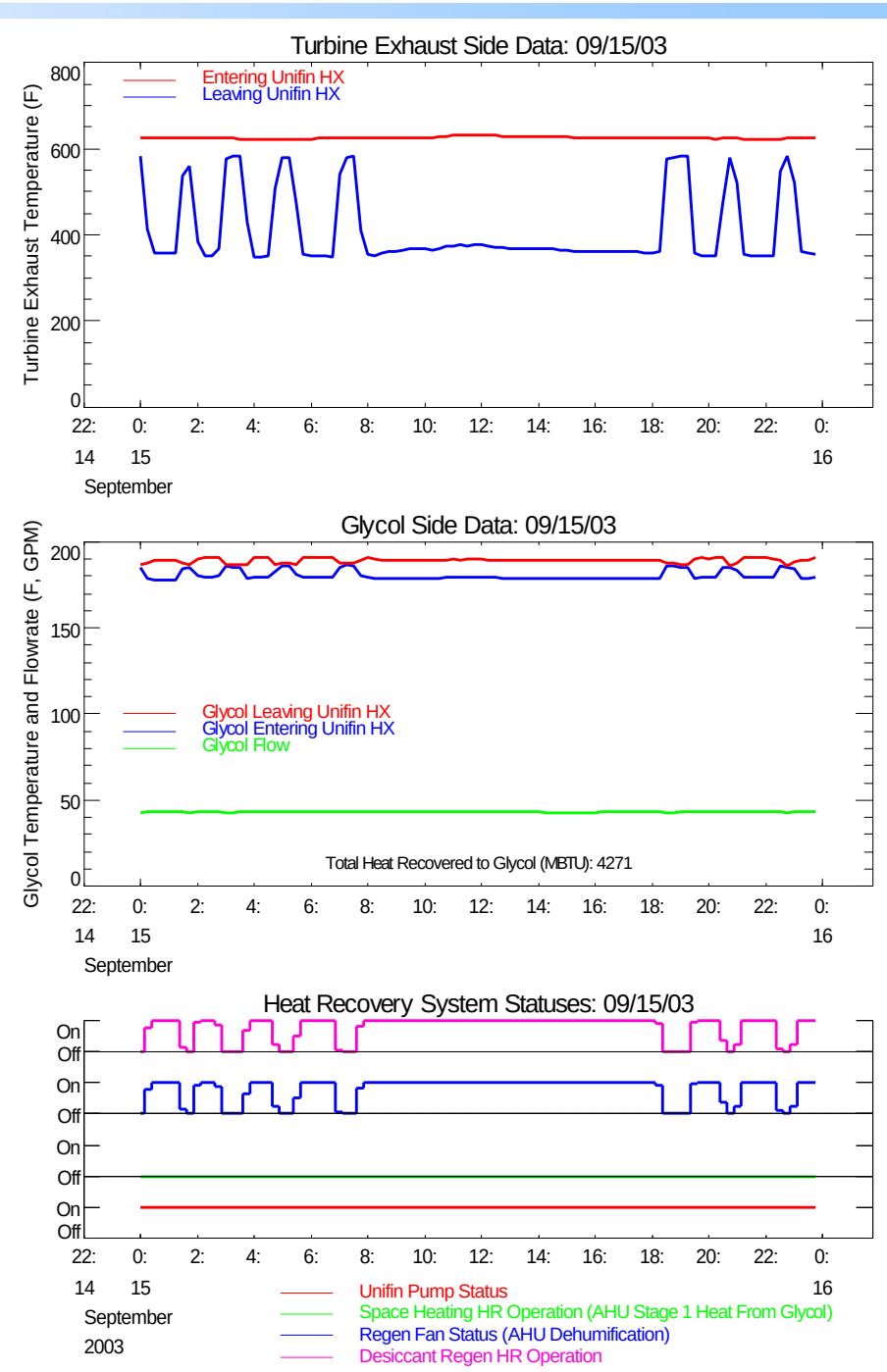
Daily Winter-Time CHP Performance

	Turbine		Parasitic Loads		Heat Recovered			
Date	Power Output (kWh)	Gas Input (MBTU)	Gas Compressor (kWh)	Heat Recovery Glycol Pump (kWh)	Space Heating (MBTU)	Desiccant Regen (MBTU)	"Net" Turbine Generation Efficiency (%)	"Net" CHP Efficiency (%)
Dec 1, 2003	0.0	0	0.0	0.0	0	0		
Dec 2, 2003	0.0	0	0.0	0.0	0	0		
Dec 3, 2003	0.0	0	0.0	0.0	0	0		
Dec 4, 2003	621.1	8,417	47.9	10.4	1,578	0	23.2%	41.6%
Dec 5, 2003	1,188.0	13,727	77.4	17.0	3,110	0	27.6%	49.8%
Dec 6, 2003	0.0	0	0.0	0.0	0	0		
Dec 7, 2003	0.0	0	0.0	0.0	0	0		
Dec 8, 2003	0.0	0	0.0	0.0	0	0		
Dec 9, 2003	0.0	0	0.5	0.0	0	0		
Dec 10, 2003	0.0	0	0.0	0.0	0	0		

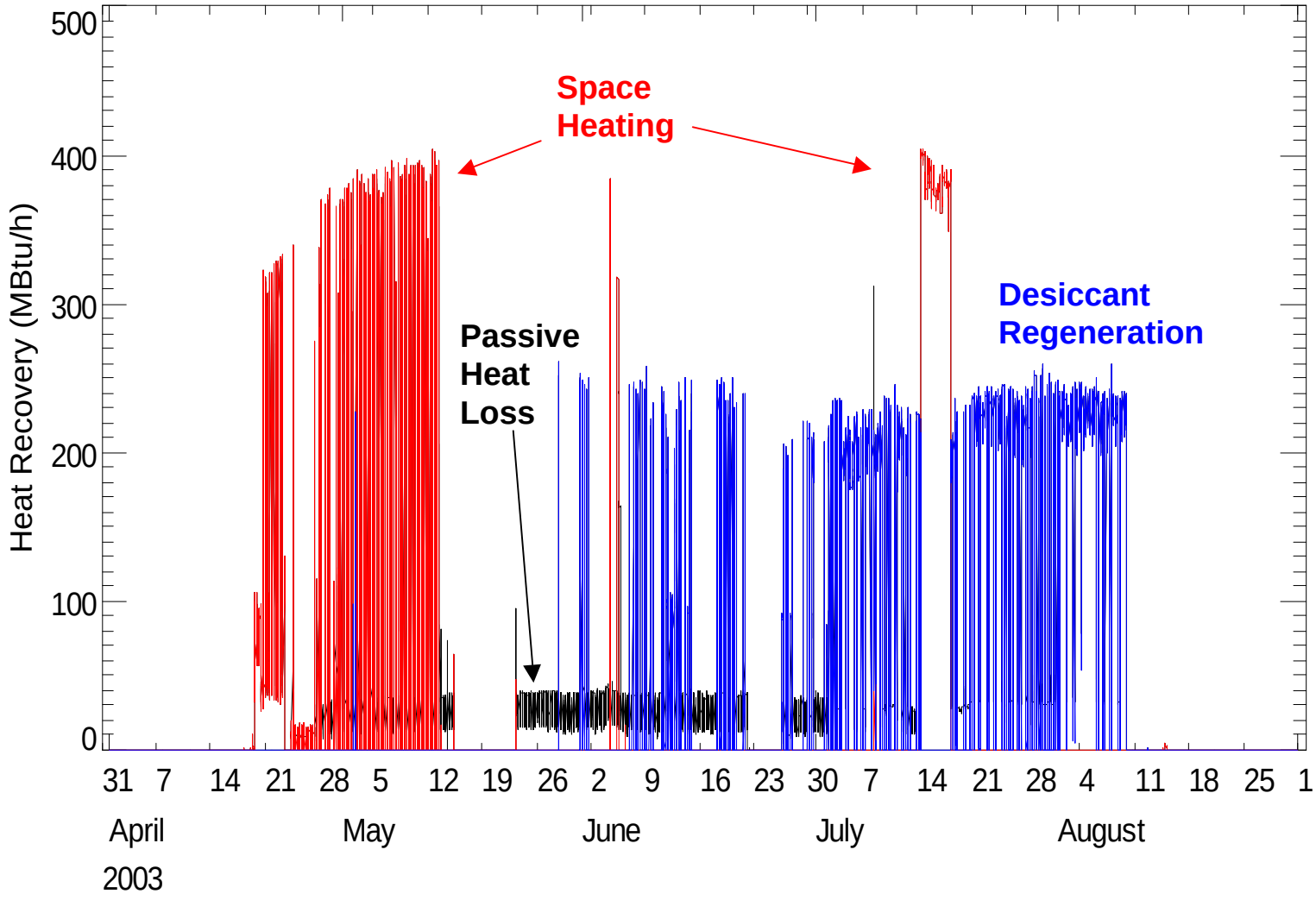
Turbine Efficiency Trend



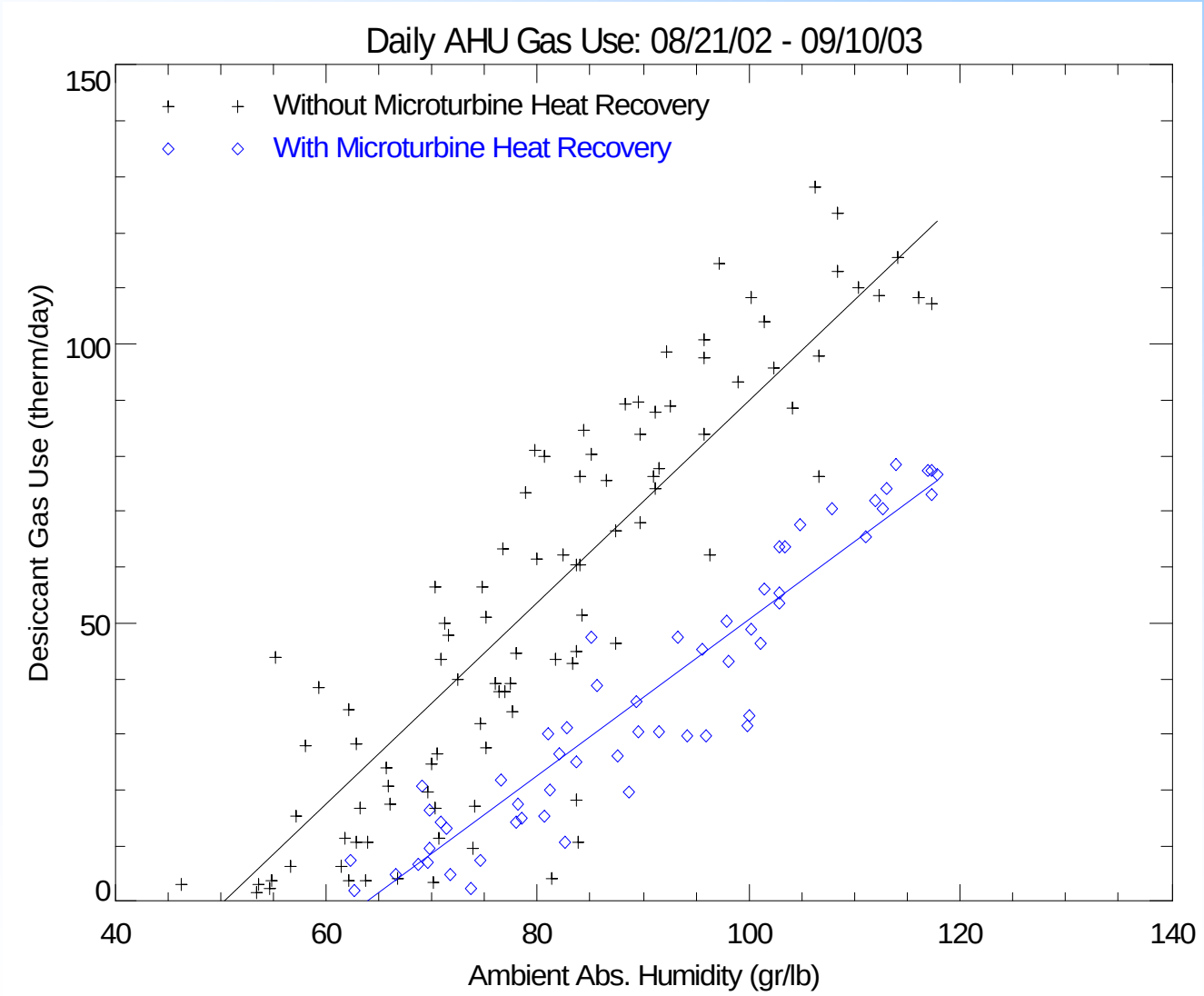
Typical Performance of Heat Recovery System



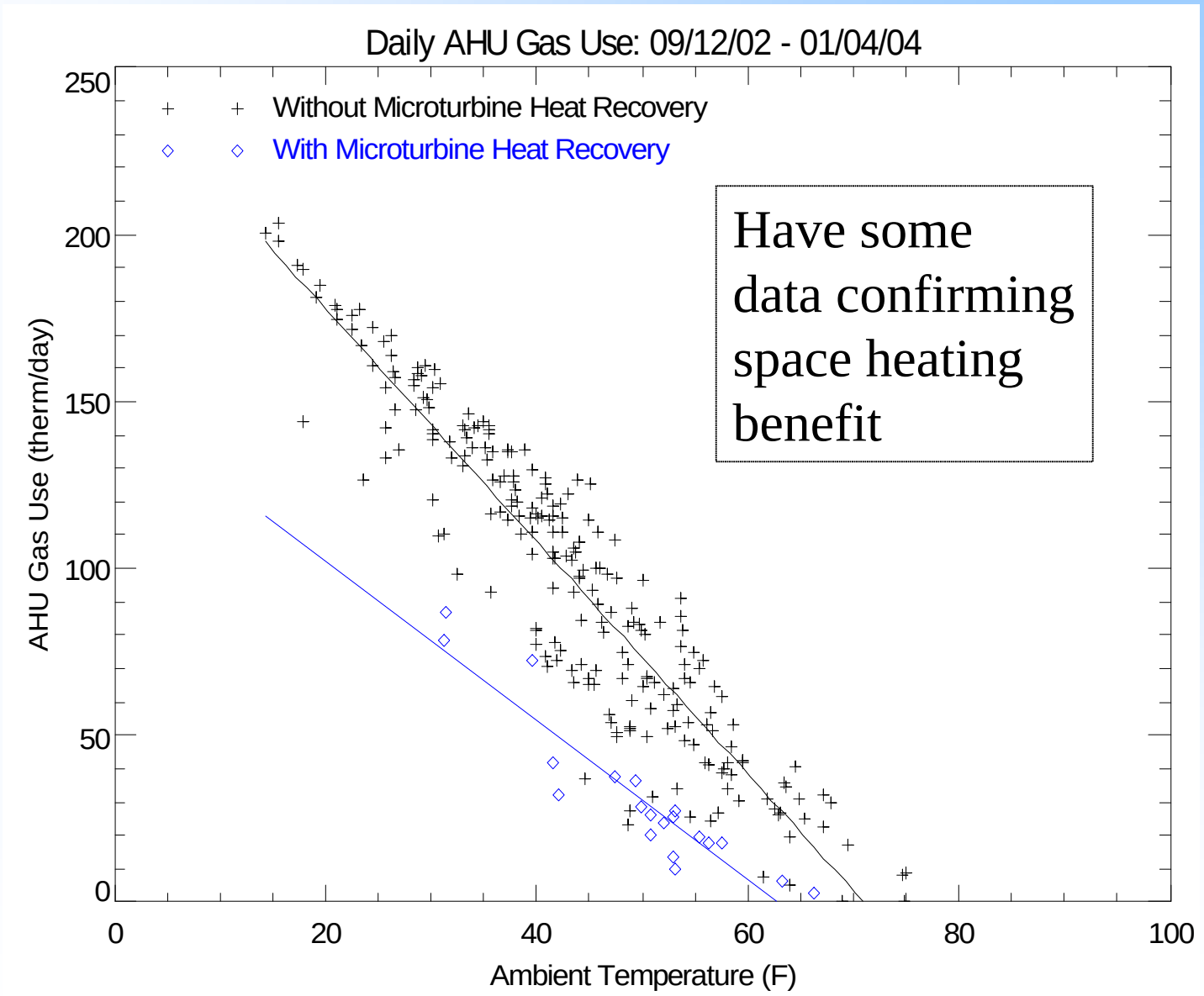
HR Rate in Different Modes



Impact of Heat Recovery on Desiccant Gas Use



HR Impact on Space Heating



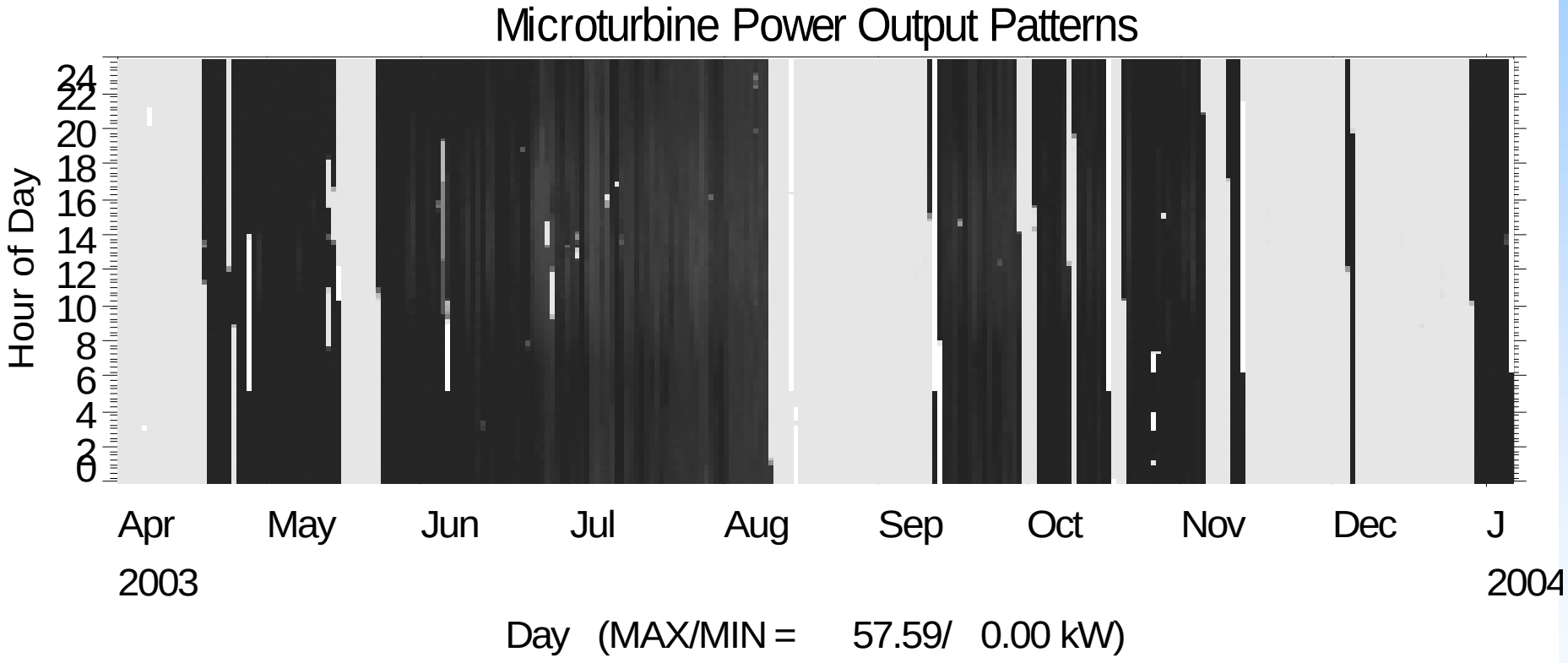
Have some data confirming space heating benefit

ETV Emissions Testing

- NYSERDA funded Environmental Technology Verification (ETV) testing at this site
- High-precision testing in June 03 confirmed CDH's thermal and power measurements
- Also collected emissions data:

	Capstone Rated Performance	Measured Performance
Nitrogen Oxides - NO_x (ppmv @ 15% O_2)	< 9	3.1
Carbon Monoxide - CO (ppmv @ 15% O_2)	< 40	3.7
Total Hydrocarbons - THC (ppmv @ 15% O_2)	< 9	0.9

Shade Plot of Turbine Operation



Turbine Availability Since April 18 2003 ~ 60-65%

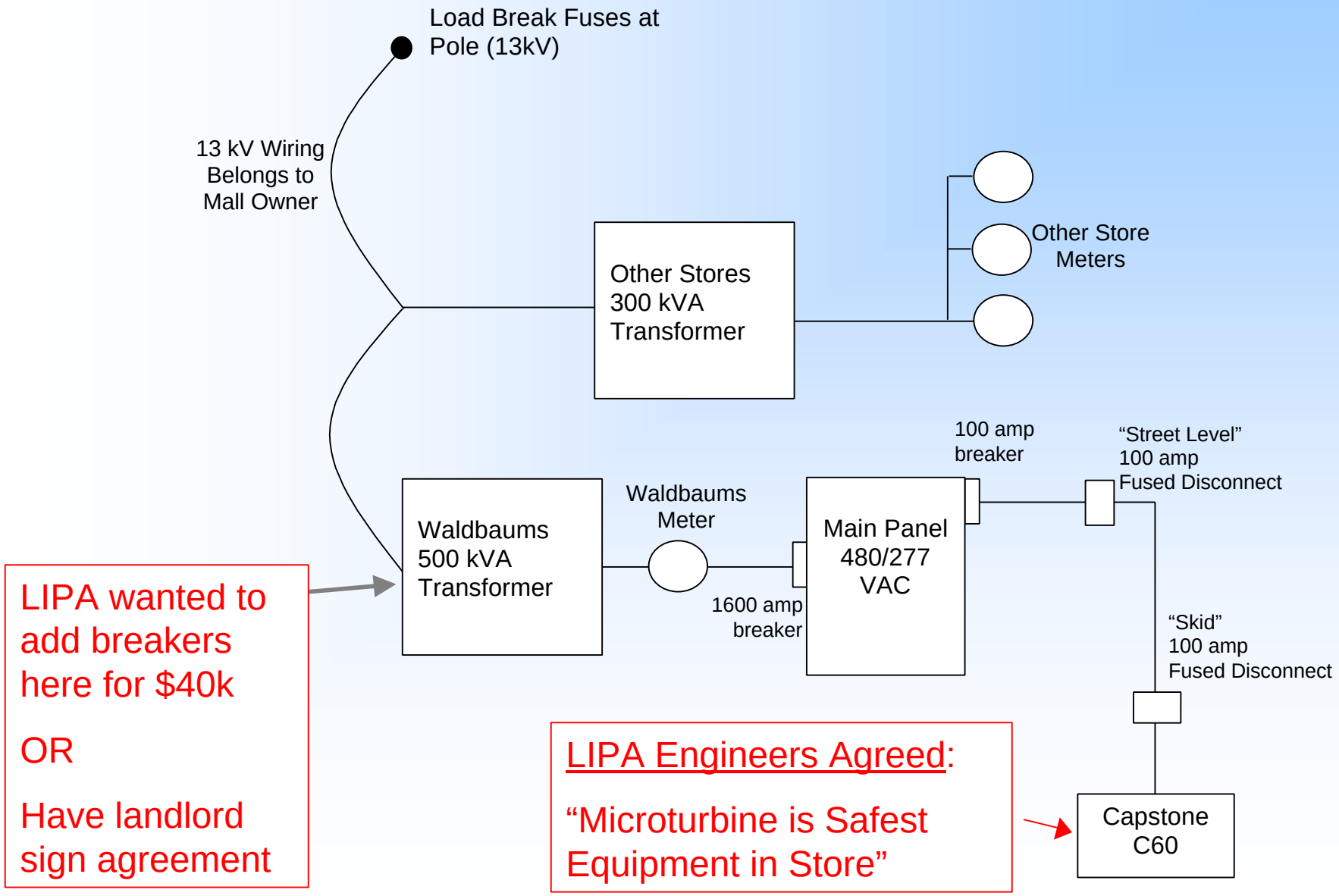
Incident History

- April. Various grid faults. Enabled auto-start.
- May 15. Ground fault in main switchgear tripped. Protective setting tightened.
- August 10. Igniter/exciter failure. Replaced.
- August 29. Unifin stack damage from gas buildup when starting. Auto-start disabled.
- October & November. Various grid faults
- November 13. Could not start after grid fault. Intake cowling/engine needed to be replaced.
- December 5. Snow shorted pwr electronics. “Snow shroud” added.

Utility Interconnection Issue

- LIPA uses NYS Standard Interconnection Agreement and microturbine was “Type-Tested”
- BUT… details with site-specific electrical feed caused problems
  - non-radial electrical feed at the site required property owner to be involved
  - administrative issue, <u>not a technical/safety issue</u>
  - highlighted issues about interconnection in *commercial tenant/owner properties*

What is a Non-Radial Feed?



LIPA wanted to add breakers here for $40k

OR

Have landlord sign agreement

LIPA Engineers Agreed:

"Microturbine is Safest Equipment in Store"

Manufacturer Support

- Manufacturer field support good after initial glitches
  - Capstone took responsibility for Unifin HX
  - Relationship details ironed out
  - Local Carrier technicians now supporting unit (within 10 miles of store)

The Future

- Integrating CHP into supermarket design would greatly lower costs
  - high installation costs result of “change orders”
- Equipment needs to be maintained and operated by 3rd parties
  - Supermarket operators are not in the power business
  - Supermarket chains are receptive to non-standard business models

More Information

- CDH Online Monitoring & Project Reports:
  www.cdhenergy.com
    click on: Online data access – Waldbaums
    (user/pass: waldbaums/microturbine)
- ETV Report
  www.epa.gov/etv/verifications/vcenter3-3.html
  (sep 03 report)